Attributes for Engineering Accreditation

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Abstract

Recently, the American Society of Civil Engineers sponsored an Education Conference to recommend changes for the Civil Engineering curriculum. In addition, various studies have been conducted to investigate methods to strengthen undergraduate education.

The present study suggests that both practicing engineers and undergraduate/graduate students believe that 3 educational attributes have been and should optimally be incorporated into the engineering program at a high level. They include: an ability to apply knowledge of mathematics, science, and engineering; an ability to identify, formulate and solve engineering problems; and an understanding of professional and ethical responsibility. In contrast, all three groups rate a knowledge of contemporary issues at a relatively lower score. The foregoing attributes are among those that have been proposed by the Accreditation Board for Engineering and Technology (ABET) as criteria that should be satisfied in order to be awarded an accredited engineering degree.

Introduction

Over the years there have been studies conducted by employers and various technical/professional organizations to revise the engineering curriculum to ensure that students are prepared for the future engineering workplace.^{3, 7} Practicing engineers and educators have also indicated that they are not completely satisfied with the average engineering program.^{4, 8} This paper reviews a number of recommendations concerning possible changes in engineering education. In addition, it presents the results of an investigation of the perceptions of a group of undergraduate and graduate students as well as practicing engineers.

The data for the study was obtained from a survey instrument which was distributed to students enrolled in various civil engineering degree programs as well as a group of practitioners attending an alumni meeting. Respondents were requested to indicate whether, and at which particular level, various educational attributes have been and should optimally be incorporated into the curriculum. The attributes consist of 11 items which future students of accredited programs may be required to satisfy.¹

Engineering Accreditation

Recently, there have been recommendations from educators and technical/professional societies to revise the engineering curriculum that is being required in accredited institutions.^{1, 6} One item of concern is the lack of teamwork in design classes.¹⁰ In this regard, it has been mentioned that good engineering consists of the following:⁹

- Trial and error;
- Cooperation and collaboration; and
- Spatial visualization.

In fact, many educators now realize that students do not always have to work alone and that learning, itself, may be enhanced by communal interaction.⁹

It has been observed in some institutions that students appear to enroll in engineering with expectations of high economic reward. However, failure to link acceptable academic performance to economic rewards has often resulted in a degree of disillusionment and substandard academic performance.⁵ Here, a broad-based curriculum that focuses on engineering as a whole might be needed to stimulate student interest.

This concept has also been adopted by the joint task force on engineering education assessment which has proposed that undergraduate engineering education must be a foundation for lifelong learning. In fact, it has been recommended that engineering undergraduates should receive a broad education in the tradition of the liberal arts.² In this regard, the Accreditation Board for Engineering and Technology (ABET) has published a report, “ABET Engineering Criteria 2000,” which includes criteria for accrediting engineering programs.¹ Specifically, the reports lists 11 attributes of an engineer. They include:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to design and conduct experiments, as well as to analyze and interpret data;
- an ability to design a system, component, or process to meet desired needs;
- an ability to function on multi-disciplinary teams;
- an ability to identify, formulate, and solve engineering problems;
- an understanding of professional and ethical responsibility;
- an ability to communicate effectively;
- the broad education necessary to understand the impact of engineering solutions in a global/societal context;
- a recognition of the need for and an ability to engage in life-long learning;
- a knowledge of contemporary issues; and
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The proposed criteria also recommends that, in the future, all students graduating from accredited engineering programs must demonstrate competence and proficiency in the above attributes.

Undergraduate Ratings of ABET Attributes

As a segment of a continuing review of the curriculum, a survey instrument was distributed to students enrolled in a required senior and a typical graduate course offered by the Civil Engineering Department of Lamar University. The questionnaire listed 11 educational attributes and requested respondents to rate the level at which each attribute has been and should optimally be incorporated into the curriculum. The educational attributes chosen are those that have been

proposed as a criteria for accreditation. They were included in the program outcomes and assessment section of the recent “ABET Engineering Criteria 2000” report and are listed in the previous section.¹

Specifically, the findings suggest that most of the educational attributes have been or should optimally be incorporated into the curriculum at a reasonable level. For example, Table 1 shows that undergraduate students believe that three attributes, which have a composite score of 3.5 or above, are presently treated or are recommended to be treated at a high level. They include:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to identify, formulate and solve engineering problems; and
- an understanding of professional and ethical responsibility

In addition, the 4 areas listed below received a minimum score of 3.3 in both categories:

- an ability to design a system, component, or process to meet desired needs;
- an ability to communicate effectively;
- the broad education necessary to understand the impact of engineering solutions in a global/societal context; and
- a recognition of the need for and an ability to engage in life-long learning.

The 7 areas listed above are perceived by undergraduate students to be covered at a high level. Nevertheless, as shown in Table 1, one attribute -- a knowledge of contemporary issues -- is rated at a composite score of ≤ 3.1 . Indeed, some individuals believe that gaining knowledge in this area should be considered to be the student's own responsibility.

Graduate Student Rating of ABET Attributes

The perceptions of graduate students are shown in Table 2. Here, the respondents indicate that 4 attributes are presently covered or are recommended to be covered at a level of 3.5 or above. They include:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to identify, formulate and solve engineering problems;
- an understanding of professional and ethical responsibility; and
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Four other areas, listed below are rated with a minimum score of 3.3 in both categories:

- an ability to function on multi-disciplinary teams;
- an ability to communicate effectively;
- the broad education necessary to understand the impact of engineering solutions in a global/societal context; and

- a knowledge of contemporary issues.

Graduate students perceive that the aforementioned 8 areas are or should be covered at a high level. In fact, a review of the data suggests that many of the attributes are included in the tabulation for both undergraduate and graduate students. Nevertheless, the ratings in the present category tend to be, overall, slightly less than those in the recommended category. This indicates that additional departmental resources may be necessary in specific areas.

Practitioner Ratings of ABET Attributes

Practicing Engineers attending an alumni conference were also requested to complete the survey instrument. In this case, the respondents were limited to indicating the level at which each attribute should be included in the civil engineering curriculum. The recommendations are illustrated in Table 3. As shown, 7 attributes were rated with a composite score of 3.5 or above. They include:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to design and conduct experiments, as well as to analyze and interpret data;
- an ability to identify, formulate, and solve engineering problems;
- an understanding of professional and ethical responsibility;
- an ability to communicate effectively;
- a recognition of the need for and an ability to engage in life-long learning; and
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

It is noteworthy that one attribute -- a knowledge of contemporary issues -- received a relative low score, 3.1. This is similar to the rating given this item by undergraduate students, 3.1. Again, the perception may be that gaining knowledge of information in this area should be the individual student's responsibility.

Summary and Conclusions

This paper reviews a number of recommendations involving engineering education. In addition, it presents the results of an investigation of the perceptions of practitioners and a group of undergraduate/graduate engineering students concerning the level at which various educational attributes have been and are recommended to be incorporated into the curriculum. Data for the study was obtained from a questionnaire which was completed by practicing engineers and students enrolled in various civil engineering degree programs.

In particular, the results suggest that students and practitioners believe that 3 educational attributes have been and should optimally be incorporated into the program at a high level. They include:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to identify, formulate and solve engineering problems; and

- an understanding of professional and ethical responsibility.

These areas may be considered to represent, in part, the traditional technical aspects of engineering.

In addition to the above, all three groups indicated that an ability to communicate effectively was important for engineering students. Undergraduate/graduate students also believe that the broad education necessary to understand the impact of engineering solutions in a global/societal context is important. In contrast, undergraduates and practicing engineers do not perceive that a knowledge of contemporary issues is extremely important. In this regard, practitioners also give an ability to function on multi-disciplinary teams a relatively low score, 3.1.

Generally, the findings suggest that practicing engineers and students appear to perceive that most ABET educational attributes have and/or should be incorporated into the civil engineering program at a reasonably high level. The attributes chosen are those that are listed in the “ABET Engineering Criteria 2000” report. They include the proposed criteria that, if adopted, all students from accredited engineering programs must satisfy in order to be awarded an engineering degree.

References

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Biographical Data

Dr. Enno “Ed” Koehn is Professor and Chair of the Department of Civil Engineering at Lamar University, Beaumont, TX. Professor Koehn has served as the principal investigator for several construction research and development projects and has experience in the design, scheduling, and estimating of facilities. In addition, he has authored/co-authored over 100 papers in engineering education as well as civil and construction engineering.

Table 1. Undergraduate Students' Perception of Education Attributes

<u>Educational Attribute</u>	<u>*Level/Standard Deviation of Educational Attributes</u>	
	<u>Present Level</u>	<u>Recommended Level</u>
An ability to apply knowledge of mathematics, science, and engineering	3.6/.49	3.8/.54
An ability to design and conduct experiments, as well as to analyze and interpret data	3.2/.98	3.6/.71
An ability to design a system, component, or process to meet desired needs	3.3/.57	3.7/.70
An ability to function on multi-disciplinary teams	3.2/.75	3.6/.71
An ability to identify, formulate and solve engineering problems	3.5/.50	3.7/.70
An understanding of professional and ethical responsibility	3.5/.62	3.5/.72
An ability to communicate effectively	3.3/.79	3.5/.72
The broad education necessary to understand the impact of engineering solutions in a global/societal context	3.4/.61	3.6/.71
A recognition of the need for and an ability to engage in life-long learning	3.4/.61	3.3/.60
A knowledge of contemporary issues	3.0/.97	3.1/.94
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	3.1/.93	3.6/.71

*Composite score based upon 4.0 = High; 3.0 = Average; 2.0 = Low; 1.0 = Unsure or None.

Table 2. Graduate Students' Perception of Education Attributes

<u>*Level/Standard Deviation of Educational Attributes</u>		
<u>Educational Attribute</u>	<u>Present Level</u>	<u>Recommended Level</u>
An ability to apply knowledge of mathematics, science, and engineering	3.5/.60	3.8/.36
An ability to design and conduct experiments, as well as to analyze and interpret data	3.1/.94	3.7/.46
An ability to design a system, component, or process to meet desired needs	3.2/.59	3.5/.60
An ability to function on multi-disciplinary teams	3.3/.78	3.6/.59
An ability to identify, formulate and solve engineering problems	3.5/.60	3.7/.57
An understanding of professional and ethical responsibility	3.5/.68	3.6/.49
An ability to communicate effectively	3.3/.55	3.5/.50
The broad education necessary to understand the impact of engineering solutions in a global/societal context	3.4/.81	3.4/.75
A recognition of the need for and an ability to engage in life-long learning	3.2/1.04	3.4/.58
A knowledge of contemporary issues	3.3/.78	3.3/.80
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	3.5/.60	3.5/.60

*Composite score based upon 4.0 = High; 3.0 = Average; 2.0 = Low; 1.0 = Unsure or None.

Table 3. Engineers' Perception of Education Attributes

	*Level/Standard Deviation of Educational Attributes
<u>Educational Attribute</u>	<u>Recommended Level</u>
An ability to apply knowledge of mathematics, science, and engineering	3.9/.34
An ability to design and conduct experiments, as well as to analyze and interpret data	3.6/.62
An ability to design a system, component, or process to meet desired needs	3.3/.81
An ability to function on multi-disciplinary teams	3.1/.67
An ability to identify, formulate and solve engineering problems	3.9/.34
An understanding of professional and ethical responsibility	3.6/.76
An ability to communicate effectively	3.7/.47
The broad education necessary to understand the impact of engineering solutions in a global/societal context	3.2/.70
A recognition of the need for and an ability to engage in life-long learning	3.5/.56
A knowledge of contemporary issues	3.1/.75
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	3.7/.53

*Composite score based upon 4.0 = High; 3.0 = Average; 2.0 = Low; 1.0 = Unsure or None.